

SOUTH POLE-AITKEN BASIN MISSION (SPAM). C. M. Weitz¹, R. A. Yingst¹, M. Minitti¹, J. W. Head III¹, L. Prockter¹, J. M. Dahl¹, C. D. Cooper¹, L. Crumpler¹, R. Gershman², R. Welch², and the Jet Propulsion Laboratory Team X², ¹Department of Geological Sciences, Brown University, Box 1846, Providence, RI 02912, ²Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109.

Introduction: Recent Clementine data of the farside of the Moon has shown high resolution details of the South Pole-Aitken basin. The basin is over 2500 km in diameter, making it the largest impact basin thus far identified in our Solar System. Estimates for the excavation depth from the basin suggest that the lower crust/upper mantle may have been reached [1, 2, 3, 4]. Clementine UVVIS data show noritic compositions [5] and high FeO wt% compositions [6], supporting that at least the lower crust may have been excavated. Because the geology of the area offers a unique opportunity to study the stratigraphy of the lunar crust at depth as well as the composition of rocks from the lunar farside, we have selected a site in the South Pole-Aitken basin for a sample return mission. Although the mission described below is currently unsuitable as a Discovery class mission, other scenarios are still possible that will reduce the mass and make the mission more feasible.

Science Objectives: There are three major science objectives for this mission: (1) *Determine the crustal structure and composition of the farside of the Moon.* Three rock samples will be targeted for collection and analysis to meet this objective, including highland, mare, and lower crust/mantle rocks. Mare samples can be used to determine the ages of farside volcanism and understand how the petrology and nature of volcanism on the farside compares to that on the nearside. (2) *Detailed study of a large lunar impact basin.* Dating of impact melt and breccia samples may determine the age of both the South Pole-Aitken and Apollo basins for better dating of lunar history and stratigraphy. By combining multispectral images with sample information, this mission will provide a detailed understanding of the impact and basin formation processes, such as the depth of excavation. (3) *Understanding of lunar formation and evolution.* Determining the stratigraphy of the lunar crust and dating these samples will improve our understanding of how the Moon formed and evolved through time. Once the composition and petrology of farside samples are determined, they will be used to test and modify the magma ocean model for lunar evolution. Finally, the mission will allow us to compare the Moon's history to the Earth's.

The Landing Site: The South Pole-Aitken basin Mission (SPAM) has been targeted for a landing site at 38.22°S, 206.7°E inside the smaller, 500 km diameter Apollo basin. The landing site is within a few kms of the inner ring of Apollo and we intend to collect samples exposed from depth by the both the South Pole-Aitken and younger Apollo basins at the uplifted ring. The landing site is most likely dominated by impact melt from the Apollo basin formation which is why we will send the rover towards the ring until highlands samples have been identified. Mare basalt to

the northeast and south of the landing site has partially filled in the Apollo basin. Although the landing site is 40 km from the nearest mare, we will look for mare samples that have been ejected from impacts and deposited near the landing site for analysis and collection.

Instrumentation: The mission will consist of an orbiter, a lander/return vehicle, and a rover. Because the landing site is on the farside of the Moon, a direct communication link to the Earth is not possible and an orbiter will be used to relay data and commands from the rover and lander to the Earth. The orbiter will also carry a multispectral camera with 192 spectral channels in the UVVIS/NIR to expand upon the coverage of the Clementine data sets. Due to data storage and communication restrictions, only images of the South Pole-Aitken basin will be taken producing a 600x600 km² mosaic of the basin at the end of the mission.

The lander/return vehicle will carry the rover to the surface and will have the return vehicle to bring the samples back to Earth. During descent to the lunar surface, a small camera at the base of the lander will take photographs which will be relayed to the orbiter and then back to Earth to aid in the location of the landing site and to provide high resolution images of the geology of the area for later interpretation and selection of the rover traverse direction. As a contingency in case the rover fails to return any samples to the lander, the lander will collect a 1-m drill core at the site for analysis back on Earth. Heat flow measurements will be made at the bottom of the drill using an instrument similar to that flown on the Apollo missions to compare heat flow on the farside to that on the nearside. Additionally, the drill core will be very useful because it will contain many small samples representing a variety of rocks from the surrounding geology.

After landing, the rover will be deployed from the lander. The current specifications for the rover are 76 cm in height, 96 cm in length, and 72 cm in width, with 30 cm diameter wheels. The rover will initially make a baseline traverse only a few meters from the lander and collect a few representative samples from the site. Based upon the rock types identified and collected during this initial traverse, the direction for the next rover traverse will be determined.

The rover is equipped with stereo multispectral cameras and a laser projection system to be used for navigation. On the right side of the front of the rover will be a 2-m long instrument deployment arm. The arm will contain a stereo panoramic imaging system that will send back pictures taken at human eye level to be used to determine the path of the rover. Also at the end of the arm will be an XRF instrument. The XRF will be placed on or near an interesting rock or soil sample for analysis and, when combined with

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spectral images taken by the rover camera, will be used to infer the petrology and mineralogy of the rocks and surface materials. If the material is worthy of collection, a second arm on the rover located at the front left will collect the sample and store it in a carousel. We had considered using a drill or rock chipper on the rover arm to remove specific areas of interest from larger rocks but deemed this too impractical. Therefore, we will only collect smaller samples that will fit into the carousel slots ($2 \times 5 \times 3 \text{ cm}^3$).

There will be three sample carousels stored in the lander but only one will be carried by the rover during a traverse. Each carousel will have 15 slots that rock and soil samples can be stored in. Once a carousel is filled, the rover will place it into the lander storage space and remove an empty carousel from the lander for its next traverse. We employ a magnetic system for transfer of each carousel from rover to lander after the rover has docked with the lander, requiring that the rover sampling arm be equipped with a magnet and be capable of moving the carousel back and forth between the rover and lander. The first carousel will be filled during the initial baseline traverse around the lander while the other two carousels will be filled during subsequent traverses.

Every 50 m or so, the rover will stop at a local high point for 10 minutes during which time it will acquire and send a panoramic image back to Earth. This image will be studied by scientists and engineers to determine the next traverse and commands will be relayed back to the rover. Most of the time the rover will function autonomously using commands previously sent from Earth. Only when in trouble or when a target rock has been identified will direct communication with the rover be used.

Mission Design: After a launch in 2001 and reaching lunar orbit, the lander+rover will be released for descent and landing on the surface while the orbiter will be placed into a 700 km orbit. At this orbit, there will be 95 minutes of communication between the orbiter and Earth for each 3 hour orbit, with 25 mins used for lander-orbit-Earth communication. The nominal time for the mission is 1 lunar day, equivalent to 1 terrestrial month, although there is the possibility for continued use of the orbiter and its multispectral camera if funding exists to obtain more regional to global coverage. The rover will not have any heating equipment to enable it to survive the lunar night. Because the entire mission occurs during the lunar day, both the lander and rover will be solar-powered.

At the end of the mission, the sample return capsule on the lander will ascend from the lunar surface and return directly back to Earth. It is equipped with a parachute for deployment in the Earth's atmosphere and

will be picked up after landing in the ocean. The sample carousels and the drill core will then be extracted for analysis by scientists.

Our first estimate of launch mass was 5000 kg. This is far in excess of the capabilities of available launch vehicles (1300 kg for Delta 2, 3000 kg for Delta 3 or Atlas). However, the launch mass is extremely sensitive to the lunar ascent vehicle mass (a 15:1 ratio) and studies under way at JPL show promise of applying new technology to reduce the mass of ascent vehicle structure, propulsion hardware, and other elements sufficiently to make this and similar sample return missions feasible.

Another scenario we considered, once we realized the mass constraints, involved turning the mission into an in-situ sample analysis mission with no samples to be returned. In addition to the XRF instrument, an APX would be added to the rover arm to provide a more detailed analysis of the rock and soil samples. Without the additional propellant for the ascent stage from the lunar surface, other instruments could be added while the mass constraints would still be met for a Delta II launch. It should be noted that the rover could still collect samples that hopefully would be returned at a later date as part of another mission.

Conclusions: NASA recently assembled a roadmap for future missions and included in this list was a lunar giant basin sample return mission. We have described a scenario to land on the lunar farside in the South Pole-Aitken basin to selectively analyze and collect samples that will answer fundamental lunar science questions. In addition, this mission will develop technology for sample collection that can be applied to future sample return missions to Mars, which is currently a high priority target for NASA. SPAM would be a relatively low risk, low cost mission useful in preparation for a martian sample return mission and we can learn a great deal from both the science and technology acquired from this lunar mission.

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